2007 NYS IPM Agricultural Grants Program – Progress Report

Project Type: Research and Development

Title: Agronomics and Economics of potato leafhopper (PLH)-resistant alfalfa intercropped with perennial forage grass for PLH control

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Abstract: Potato leafhopper (PLH) is the most damaging alfalfa pest in the Northeast (NE). Forage grasses mixed with alfalfa can cause PLH to emigrate but may reduce forage quality. Some alfalfa cultivars have PLH-resistance, yet are not immune to PLH damage. The objectives are to compare PLH populations and densities, and forage yield and quality of a conventional alfalfa cultivar and a PLH-resistant cultivar both in monoculture and intercropped with grass, to conduct an economic analysis, and to share results in extension outreach. The PLH populations and forage growth were disappointingly low in 2007, in part due to drought conditions. In spite of this, PLH damage scores indicated that the PLH-resistant cultivars have less leaflet yellowing than the conventional alfalfa cultivars, and the alfalfa-grass mixtures have less leaflet yellowing than the alfalfa monocultures. However, at low PLH populations, these small but statistically significant differences did not translate into differences in yield between the PLH-resistant and conventional cultivars. The alfalfa-grass mixtures were significantly higher in yield than the alfalfa monocultures. Thus, results from one production year at one location, have shown that without insecticide treatment, PLH-resistant alfalfa planted with a forage grass could provide the highest forage yield.

Background and Justification:
It is estimated that two-thirds of the alfalfa acreage in the NE include a perennial forage grass, most often timothy (*Phleum pratanse* L.) or orchardgrass (*Dactylis glomerata* L.).

Potato leafhopper (PLH) is the most widespread and damaging insect pest of alfalfa in the NE, causing risk to new seeding establishment and survival, and to established stands during mid-to-late summer. When high populations of PLH are not controlled during the establishment year, large reductions in alfalfa yield and quality can occur (Flinn and Hower 1984, Davis and Fick 1995, Hansen et al., 2002).

To minimize risk and avoid economic impacts growers are encouraged to monitor crops frequently and, when PLH populations warrant, harvest the forage early or treat with a properly labeled insecticide. Unfortunately, many insecticides currently registered for alfalfa bear the restriction “Apply only to fields planted to pure stands of alfalfa” and as such are not

appropriately labeled for mixed stands of alfalfa:clover:grasses, Only in 2007 did producers in NY get a labeled insecticide to use on mixed stands (Mustang).

In years of severe PLH infestations, early forage harvest alone will not adequately control insect populations. The establishment year is when PLH populations can cause the most damage (Flinn and Hower, 1984). Frequent early harvest and excessive PLH injury in the establishment year of spring seedings can weaken alfalfa making the field susceptible to winter injury and disease. In addition to early harvest, other non-pesticide PLH management techniques include the use of PLH-resistant alfalfa cultivars and planting perennial grass as a companion crop to the alfalfa.

Potato leafhopper-resistant alfalfa cultivars first became commercially available in 1997 and offer producers a degree of relief from PLH damage. Alfalfa breeders successfully incorporated glandular-hairs from perennial wild-type tetraploid and diploid Medicago species with resistance to PLH into modern alfalfa germplasm (McCaslin, 1994). Hansen et al. (2002) have shown that early generation PLH-resistant alfalfa cultivars, while not immune to PLH, had reduced PLH damage symptoms, were superior in feed quality than many of the conventional alfalfa cultivars tested, and were well adapted to NY growing conditions. Similar results were found in caged alfalfa experiments in Iowa (Lefko et al, 2000) and in field trials conducted in Ohio, Indiana, Wisconsin, and Minnesota (Sulc, et al, 2001).

Current seed costs of PLH-resistant cultivars are comparable to conventional alfalfa cultivars and a limited number of new PLH-resistant cultivars are available to producers. The new PLH-resistant cultivars have more than 75% resistance to PLH insects (Peterson, 2003). Recent studies by Sulc et al. (2004) suggest an alfalfa cultivar with high resistance to PLH may have an economic threshold for damage by PLH that is three to four times higher than the threshold for a conventional, non-glandular haired cultivar. From PLH sweep data, Hansen, et al. (2002) found that planting a PLH-resistant alfalfa cultivar reduced PLH numbers by an average of 47% compared to planting a conventional alfalfa cultivar. This reduction was greater in the production years than in the establishment year. Potato leafhopper resistant alfalfa cultivars may likely need to be sprayed with insecticide in the seeding year when PLH populations do the most damage, and perhaps at other times during the life of the stand when PLH populations are at particularly damaging levels.

Other researchers have found that intercropping alfalfa with grasses can reduce PLH populations. In mixtures of conventional alfalfa with either smooth bromegrass or orchardgrass, PLH populations were reduced compared to alfalfa monocultures, but not below economic thresholds (DeGooyer et al., 1999). From this same study, it was estimated that PLH numbers per alfalfa stem were not significantly lower for the alfalfa : grass intercrops than for the alfalfa monoculture. Davis and Fick (1995) reported PLH nymph populations on a per stem basis were not affected by timothy alfalfa mixtures. On a per area basis, however, nymph densities were higher in alfalfa monocultures than in alfalfa timothy mixtures. Research reported by Roda et al. (1997a), found that numbers of adult PLH were reduced by 22-48% in alfalfa : grass mixtures of either smooth bromegrass or orchardgrass. Smooth bromegrass and orchardgrass intercropped with alfalfa, planted at high densities, ca. 78% alfalfa and 22% grass, consistently had lower numbers of adult PLH than alfalfa alone. Mixtures of alfalfa with timothy showed both increases and decreases in PLH populations compared to alfalfa alone. The authors hypothesized that

overall lower percentages of timothy (7%) in the stand compared with bromegrass and orchardgrass may have contributed to this variability. Also, as alfalfa biomass in the mixture increased, leafhopper emigration decreased. Further research showed that PLH emigration resulted from physical contact with grass rather than from grass volatiles (Roda et al., 1997b). Also, monocotyledonous plants such as grasses and sedges do not sustain the development of PLH nymphs (Lamp et al., 1994). Intercropping forage grass with alfalfa could reduce PLH numbers at harvest by up to 48% (Roda, et al, 1997a).

Research data regarding potential effects of PLH on PLH-resistant alfalfa cultivars combined with a perennial forage grass species are extremely limited. Potato leafhopper populations, PLH damage to the alfalfa, yield, and forage quality were measured on PLH-resistant alfalfa planted with and without timothy (Waldron, et al, 2004). The alfalfa : grass mixture averaged 10% alfalfa, a significantly lower percentage of alfalfa in the mixture than reported in studies by Davis and Fick (1995) and by Roda (1997a). The PLH-resistant cultivar had 36% fewer PLH than the susceptible cultivar; however, the number of PLH was significantly higher than for the plots that were sprayed with insecticide (average less than 1 PLH per sub-plot). The combination of the PLH- resistant cultivar and timothy resulted in significantly better PLH control than did the resistant cultivar alone. For the plots that were not sprayed with insecticide, the plot with the lowest PLH damage was the resistant alfalfa/grass mixture (score = 1.8; score 1=no damage to 5=severe damage), whereas the resistant cultivar alone scored 2.4 and the susceptible cultivar alone and with grass averaged 3.5. This study was not continued past the seeding year due to winter injury.

The following study was designed to conduct a detailed agronomic and economic analysis of the effect of PLH-resistant alfalfa intercropped with one of three perennial forage grasses: timothy, orchardgrass, or tall fescue (*Festuca arundinacea* Schreb) on PLH populations, crop damage, and indications of profitability. This report follows the 2006 report on seeding year agronomic results and presents 2006 forage quality results and 2007 agronomic results. The results from the Geneva trial will be combined with the results from three additional identical experiments, one planted in Ithaca NY, one in RockSprings PA, and one in Landisville PA.

2006 Yield and PLH Damage – Seeding Year Summary

For conventional alfalfa not treated with insecticide, the alfalfa - grass mixture plots compared to the monoculture alfalfa plots averaged significantly lower PLH damage scores (2.7 vs. 3.2), lower number of PLH insects in 10 sweeps (19.4 vs. 30.0), and higher total season yield (2.11 t/a vs. 1.88 t/a ($P<0.0677$)). Thus, under moderate PLH damage (visual assessment) in the seeding year when PLH are not controlled with insecticides, planting a grass with conventional alfalfa was shown to reduce the numbers of PLH insects, reduce PLH damage to the alfalfa, and increase yield. For PLH-resistant alfalfa, the alfalfa - grass mixture plots compared to the monoculture alfalfa plots were not significantly different for insect damage or yield. Thus, planting a grass with PLH-resistant cultivars may be recommended for agronomic reasons, but did not reduce PLH damage and populations even further than was achieved by using a PLH-resistant alfalfa cultivar alone.

Over alfalfa monoculture and alfalfa-grass mixtures, the insecticide treated plots averaged 2.31 tons per acre dry matter compared to 2.10 tons per acre for untreated plots ($p<0.0576$). Data

from this study suggests that even though PLH-resistant alfalfa cultivars are a significant advancement in integrated pest management for PLH insects, maximum yields in the seeding year are still achieved through complete control of PLH by insecticide applications. The PLH-resistant alfalfa cultivar stayed green when a few PLH were feeding, however, this variety was still significantly stunted from this amount of feeding damage as shown by alfalfa height measurements. Through plant breeding, it may be possible to select specifically for PLH-resistant plants that are not stunted by PLH feeding.

Procedure-2007:
A field plot trial at the Cornell University - NYSAES Horticulture Research Farm in Geneva planted on May 8, 2006 was harvested and sampled in 2007, the first production year. The trial design is a split-plot with insecticide treatment as the main plot, and alfalfa and alfalfa-grass mixtures as the sub-plots. The sub-plots are either WL 347LH, an alfalfa cultivar with high resistance to PLH, or WL 357HQ, a conventional (*PLH susceptible*) alfalfa cultivar. Subplots are either clear-seeded or planted in combination with "Summit" timothy, "Intensiv" Orchardgrass, or "Enhance" Tall Fescue.

Main plots were monitored weekly for PLH populations in 2006 (21-Jun, 28-Jun, 5-Jul, 14-Jul, 20-Jul, 26-Jul, 16-Aug, 31-Aug, 6-Sep) and in 2007 (27-Jun, 5-Jul, 11-Jul, 1-Aug, 8-Aug, 14-Aug, 22-Aug, 4-Sep using standard NYS alfalfa IPM practices (10 sweeps per sub-plot). Insecticide plots were sprayed with 'Warrior' insecticide (0.2 pt/A, Zeneca Ag Products, Wilmington, DE) on 06-Jul-06, 23-Aug-06, 29-Jun-07, 15-Aug-07.

Plots were harvested 2-Aug-06, 22-Sep-06, 7-Jun-07, 18-Jul-07, 13-Sep-07. The day before Harvest 1 in 2006 and Harvest 2 and 3 in 2007, each plot was swept ten times with a standard 15 inch diameter sweep net, and the PLH adults and nymphs were counted. For nymph counts on only the alfalfa portion of the plot, ten alfalfa stems were cut from within each plot area, carefully placed in a plastic bag (one bag per plot), and placed in a cooler for counting the day after collection. Samples of each plot were hand-harvested at 5 cm cutting height. The alfalfa, grass, and weeds were separated, placed in separate paper bags, and dried at 55 degrees C. These bag weights were used to calculate %alfalfa, %grass, and % weeds for each plot, and the alfalfa and grass portions of the plots were combined for use in forage quality analyses. The height of alfalfa stems and grass canopy was measured for each plot. The alfalfa portion of the sample was rated for PLH damage on a scale of one to five where one is a sample that has no apparent or minor PLH damage and a five is a sample with severe stunting and yellowing symptoms of PLH damage (McCaslin and Miller, 1998). Following hand harvest and data collection, the plots were mechanically harvested for yield. Samples for dry matter correction were taken from every plot at harvest time. At harvest times when the PLH populations were very low, the following data were collected: hand-harvested samples for forage quality analyses, botanical composition, alfalfa and grass height, PLH damage score, and yield.

Laboratory work on samples from 2006 for forage quality analyses has been completed. Forage samples from 2007 have been dried, and percent grass and alfalfa per plot determined. Grinding of dried samples is still in progress so forage quality analysis for 2007 samples has not been completed at this time.

Although yield and other field data are available now, a more complete partial budget economic analysis will be developed when forage quality data from the first production year are available. Retail seed prices on a cost per pound basis were $3.90 for WL 347LH and for WL 357HQ, $1.36 for "Summit" timothy, $2.25 for "Intensiv" orchardgrass, and $1.54 for "Enhance" tall fescue. Insecticide cost (Warrior) if applied by a commercial applicator is estimated at $4/acre with application costs at $9/acre, for a total of $13/acre.

The data were analyzed as a split-plot by SAS Proc Mixed. Contrasts of interest were estimated and tested for statistical significance.

Results and Discussion:

Forage Quality – Seeding year – 2006 (Table 1)

For 2006 averages weighted by harvest yields, the subplots that were treated with insecticide were significantly higher in percent crude protein, lower in percent digestible neutral detergent fiber, and lower in pounds of milk per ton (predicted from MILK2000 spreadsheet, U of WI) than the subplots that were not treated with insecticide. However, insecticide treated and untreated plots did not differ significantly in predicted pounds of milk per acre. The treatment by entry interaction was not significant for any total season forage quality component so data for insecticide treated and untreated plots were combined for further analyses.

Averaged over alfalfa monoculture and alfalfa-grass mixtures, the PLH-resistant alfalfa cultivar had significantly higher percent crude protein than the conventional alfalfa cultivar. The resistant and conventional cultivars did not differ in percent neutral detergent fiber, percent digestible neutral detergent fiber, milk per ton, and milk per acre.

The alfalfa-grass mixtures averaged significantly lower percent crude protein and higher percent neutral detergent fiber than the alfalfa monocultures, as expected since grasses have lower percent crude protein and higher percent neutral detergent fiber. Furthermore, the alfalfa-grass mixtures averaged higher percent digestible neutral detergent fiber and milk per ton than the alfalfa monocultures. However, the differences in milk per acre were not statistically significant.

For the seeding year, subplot and main plot treatments did not significantly impact the pounds of milk per acre produced as predicted by MILK2000, thus PLH control by spraying or by planting PLH-resistant cultivars with or without a grass species had similar outcomes under moderate PLH damage levels (visual assessment) in the seeding year.

Agronomic Results – First Production Year – 2007

Botanical composition (Table 2): Volunteer red clover was the main weed in the plots in 2007, the first production year. The percent weeds averaged 12.7% of the plot dry matter over all treatments at Harvest 1, 4.9 % at Harvest 2, and 0.8% at Harvest 3. The grass portion of the alfalfa - grass mixture plots dry matter averaged 17.6% over three harvests. The percent grass in the alfalfa - orchardgrass plots averaged 20.7%, in the alfalfa - timothy plots averaged 16.0%, and in the alfalfa - tall fescue plots averaged 16.1%.

Main plots were monitored for PLH populations using standard NYS alfalfa IPM practices (10 sweeps per sub-plot) (Table 3). Potato leafhopper (PLH) populations in main plots remained low throughout the summer months. Averaged over 6 sub-plots and 8 sweep dates, the average number of PLH adult insects was 0.9 for the insecticide treated plots and 1.1 for the untreated plots. The average number of PLH nymphs was 0.6 for the insecticide treated plots and 0.1 for the untreated plots. Temperatures from May through August averaged 0.7 degrees higher than normal and total precipitation was 6.1 inches less than normal (Figure 1).

PLH Damage Score at Harvest 2 (Table 4)
The insecticide treatment by entry interaction was significant only for PLH damage score (visual score from 1 (no apparent damage) to 5 (severe damage)) at Harvest 2. For the insecticide treated plots, the average of the PLH-resistant alfalfa and alfalfa-grass mixture plots was 1.2 and this was significantly lower than the average of the conventional alfalfa and alfalfa-grass mixture plots (1.6; P=0.0338). For the plots not sprayed with insecticide, the average of the PLH-resistant alfalfa and alfalfa-grass mixture plots was 1.3 and this was significantly lower than the average of the conventional plots (1.8; P<0.0001). Furthermore, the average PLH damage score for alfalfa in the alfalfa-grass mixture plots that were not sprayed with insecticide was 1.5 and for the alfalfa monoculture was 1.7 (P=0.0534). Thus, even though PLH populations were extremely low, the PLH resistant cultivars had less PLH damage or leaflet yellowing than the conventional cultivars, and the alfalfa-grass mixtures had less leaflet yellowing than the alfalfa monocultures.

Yield (Table 5)
The insecticide treated plots averaged 3.88 tons per acre dry matter compared to 3.90 tons per acre for untreated plots. Averaged over all treatments, total season yield of PLH-resistant alfalfa was not significantly different from conventional alfalfa. However, yield of the alfalfa-grass mixture plots was 0.44 tons per acre higher than the alfalfa monoculture plots (P=0.0003).

Alfalfa Height, Percent Alfalfa and Grass (Table 6)
The insecticide treated plots had alfalfa that was of comparable plant height to the untreated plots. Averaged over all treatments, the plant height of PLH-resistant alfalfa was not significantly different from conventional alfalfa. However, height of the alfalfa in the alfalfa-grass mixture plots averaged 3 cm higher than the alfalfa monoculture plots at Harvest 2 (P=0.0072) and 4 cm higher at Harvest 3 (P=0.0006).

At both Harvest 2 and 3, the percent alfalfa in the plots was lower for the PLH-resistant alfalfa than for the conventional alfalfa (Harvest 2 - P=0.0098, Harvest 3 - P=0.0437). Similarly at both Harvest 2 and 3, the percent grass in the plots was higher for the PLH-resistant alfalfa plots than the conventional alfalfa (Harvest 2 - P=0.0020, Harvest 3 - P=0.0310).

PLH Populations at Harvest 2 (Table 7)
For ten sweeps per plot averaged over spray treatments, the PLH-resistant alfalfa had 1.5 fewer PLH insects than the conventional alfalfa (3.0 vs 4.5; P=0.0506).

The main effect, treatment by entry interaction, and planned comparisons were not significant for yield (at Harvest 1, Harvest 2, or Harvest 3), nymph counts per 10 stems, PLH damage score at Harvest 3, grass height, and percent alfalfa and grass at Harvest 1.

Conclusions

The PLH populations and forage growth were disappointingly low in 2007, in part due to drought conditions. In spite of this, PLH damage scores indicated that the PLH-resistant cultivars have less leaflet yellowing than the conventional alfalfa cultivars, and the alfalfa-grass mixtures have less leaflet yellowing than the alfalfa monocultures. However, at low PLH populations as seen in 2007, these small but statistically significant differences did not translate into differences in yield between the PLH-resistant and conventional cultivars. The alfalfa-grass mixtures were significantly higher in yield than the alfalfa monocultures. Forage quality analyses for 2007 (completed by spring 2008) will provide a comparison of pounds of milk per acre. Thus, results from one production year at one location, have shown that without insecticide treatment, PLH-resistant alfalfa planted with a forage grass could provide the higher forage yield and have lower leaflet yellowing than other crop combinations.

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Project location(s):

Cornell University - NYSAES Horticulture Research Farm in Geneva, New York.
Research findings applicable to northeastern US and other regions with similar alfalfa : grass production systems.

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Table 1: Forage quality data from Geneva seeding year trial – 2006. Data are for component season averages weighted by harvest yields.

	%Crude Protein	%NDF	%digestible NDF	Milk per ton (lbs)
Avg. Spray	25	42	52	3005
Avg. No Spray	22	42	54	3085
p-value (trt)	0.0084 **	0.7555 ns	0.0420 *	0.0425 *
p-value (trt*ent)	0.0777 ns	0.2139 ns	0.1207 ns	0.2653 ns
Avg. Resistant Alfalfa	24	42	53	3048
Avg. Conventional Alfalfa	23	42	53	3042
p-value (trt)	0.0005 **	0.1635 ns	0.7466 ns	0.7249 ns
Avg. Alfalfa + Grass	23	43	54	3068
Avg. Alfalfa alone	25	41	50	2976
p-value (trt)	0.0001 **	0.0001 **	0.0001 **	0.0001 **
PLH Alfalfa + Orchardgrass	23	44	55	3062
Conv. Alfalfa + Orchardgrass	23	44	55	3081
PLH Alfalfa + Tall Fescue	24	42	54	3099
Conv. Alfalfa + Tall Fescue	23	43	53	3043
PLH Alfalfa + Timothy	24	42	53	3065
Conv. Alfalfa + Timothy	23	42	54	3059
PLH Alfalfa alone	25	41	50	2965
Conv. Alfalfa alone	24	41	50	2986

Milk per ton was determined by using MILK 2000 spreadsheet (D. Undersander, Univ. of WI).
*=statistically significant at P=0.05; **=statistically significant at P=0.01, ns=not statistically significant.

Table 2. Botanical composition of alfalfa and alfalfa : grass mixture plots in Geneva NY 2007 Insecticide treatment by subplot interaction was not significant so data are averaged over insecticide treatment.

Plot Entry	R-PLH-Resistant C-Conventional	Harvest 1			Harvest 2			Harvest 3		
		%A	%Gr	%W	%A	%Gr	%W	%A	%Gr	%W
Alfalfa + OG	R	62.5	25.5	11.9	81.5	12.3	6.1	72.6	26.9	0.5
Alfalfa + OG	C	66.7	24.6	8.7	86.4	10.7	2.9	74.8	24.3	0.9
Alfalfa + TF	R	68.5	19.4	12.1	78.5	15.9	5.6	78.5	20.6	0.9
Alfalfa + TF	C	72.8	16.3	10.9	86.6	10.2	3.3	84.3	14.4	1.2
Alfalfa + Timothy	R	52.2	35.4	12.4	90.7	4.3	5.0	90.3	8.9	0.8
Alfalfa + Timothy	C	50.4	36.0	13.6	92.2	2.7	5.0	90.6	8.6	0.7
Alfalfa alone	R	87.8	0.0	12.2	95.8	0.0	4.2	99.2	0.0	0.8
Alfalfa alone	C	80.6	0.0	19.4	93.4	0.0	6.6	99.2	0.0	0.8

%A = %Alfalfa; %Gr = %Grass; %W=%Weeds

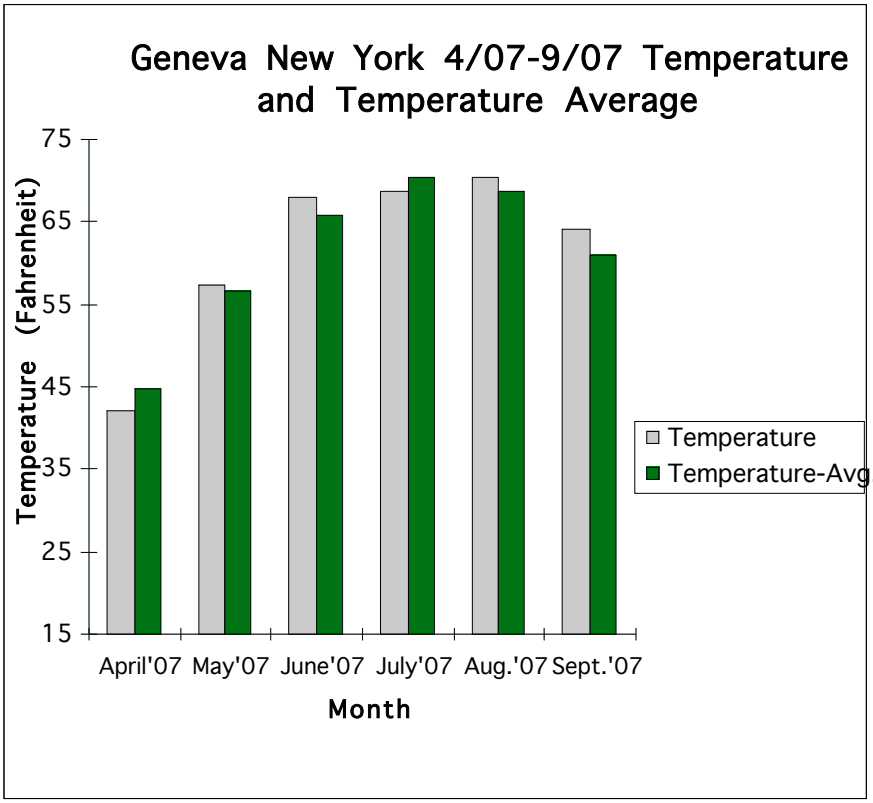
Table 3. Potato leafhopper (PLH) populations in alfalfa and alfalfa : grass mixtures at NYSAES field plots summer 2007

Insecticide applied?	Measurement	27-Jun	5-Jul	11-Jul	1-Aug
Yes	PLH adult	0	7	0	0
No	PLH adult	6	1	1	1
Yes	PLH nymph	0	0	2	0
No	PLH nymph	0	0	0	1
Yes	plant height (cm)	10.5	14.3	15.7	7.8
No	plant height (cm)	11.8	13.2	14.7	8.2

Insecticide applied?	Measurement	8-Aug	14-Aug	22-Aug	4-Sep
Yes	PLH adult	0	0	0	0
No	PLH adult	0	0	0	0
Yes	PLH nymph	1	2	0	0
No	PLH nymph	0	0	0	0
Yes	plant height (cm)	13.3	12.7	14.3	15.7
No	plant height (cm)	12.3	11.7	14.2	13.5

* Figure is sum of PLH collected in each of six main plots (10 sweeps per plot), plant heights are averages from the six main plots.

Figure 1. Temperature and precipitation in 2007 at Geneva compared to averages.



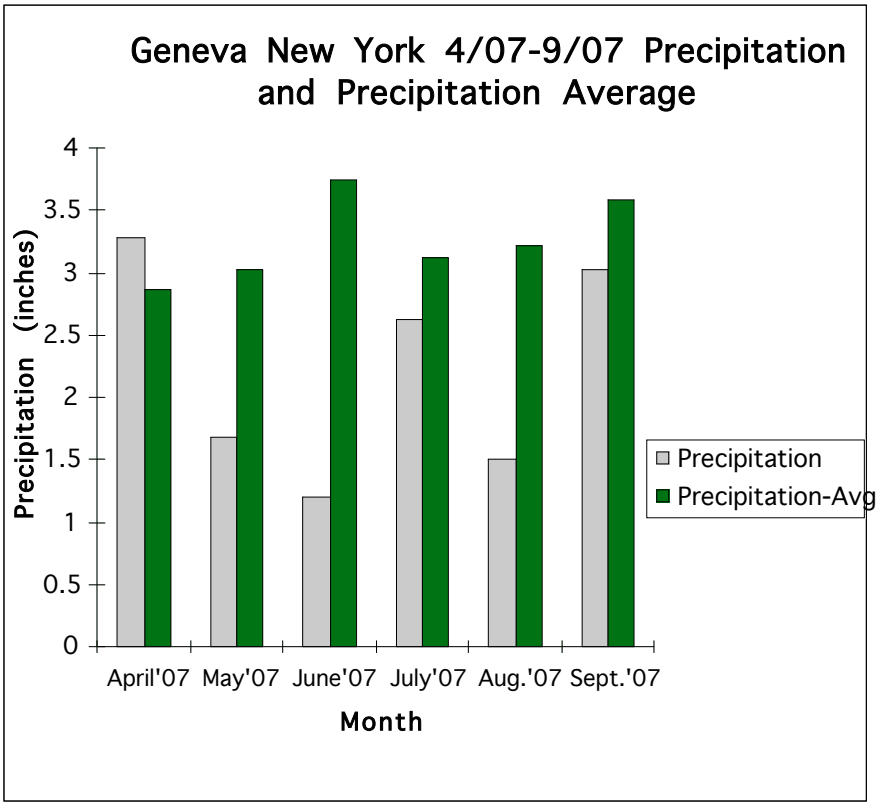


Table 4. Potato leafhopper Damage Score at Harvest 2 in 2007.

	PLH Damage Score - Harvest 2	
	Insecticide Treated	**No Insecticide**
Avg. Resistant Alfalfa	1.13	1.63
Avg. Conventional Alfalfa	1.09	1.47
p-value R vs C	0.0338 *	0.0001 **
Avg. Alfalfa + Grass	1.12	1.62
Avg. Alfalfa alone	1.06	1.33
p-value A+G vs A	0.1745 ns	0.0534 *
PLH Alfalfa + Orchardgrass	1.00	1.22
Conv. Alfalfa + Orchardgrass	1.23	1.92
PLH Alfalfa + Tall Fescue	1.03	1.28
Conv. Alfalfa + Tall Fescue	1.07	1.50
PLH Alfalfa + Timothy	1.08	1.18
Conv. Alfalfa + Timothy	1.12	1.88
PLH Alfalfa alone	1.12	1.45
Conv. Alfalfa alone	1.20	1.98

[a] 1 is no apparent injury, 2 is very minor stunting and yellowing, 3 is moderate stunting with yellowing evident on 20 to 40% of leaves, 4 is significant stunting and yellowing on 40 to 60% of leaves, and 5 is severe stunting and yellowing on 60 to 100% of leaves.

*=statistically significant at P=0.05; **=statistically significant at P=0.01, ns=not statistically significant.

Table 5: Yield in 2007

	Yield - tons per acre dry matter			
	Harvest 1	Harvest 2	Harvest 3	Total Yield
Avg. Spray	2.62	0.79	0.47	3.88
Avg. No Spray	2.61	0.77	0.52	3.90
p-value (trt)	0.8982 ns	0.8334 ns	0.3196 ns	0.9505 ns
p-value (trt*ent)	0.7999 ns	0.1055 ns	0.2206 ns	0.3277 ns
Avg. Resistant Alfalfa	2.56	0.77	0.48	3.82
Avg.Conventional Alfalfa	2.67	0.78	0.51	3.96
p-value (trt)	0.2606 ns	0.4217 ns	0.0765 ns	0.1370 ns
Avg. Alfalfa + Grass	2.67	0.78	0.50	3.94
Avg. Alfalfa alone	2.45	0.79	0.48	3.72
p-value (trt)	0.0001 **	0.8661 ns	0.0566 *	0.0001 **
PLH Alfalfa + Orchardgrass	2.56	0.79	0.53	3.88
Conv. Alfalfa + Orchardgrass	2.60	0.78	0.51	3.89
PLH Alfalfa + Tall Fescue	2.51	0.73	0.42	3.65
Conv. Alfalfa + Tall Fescue	2.87	0.85	0.54	4.25
PLH Alfalfa + Timothy	2.92	0.75	0.50	4.17
Conv. Alfalfa + Timothy	2.79	0.80	0.56	4.15
PLH Alfalfa alone	2.34	0.79	0.43	3.56
Conv. Alfalfa alone	2.33	0.75	0.47	3.55

*=statistically significant at P=0.05; **=statistically significant at P=0.01, ns=not statistically significant.

Table 6. Planned comparisons for Alfalfa height and botanical composition for Harvest 2 and 3 in 2007.

	Alfalfa Height (cm)		%Alfalfa	%Grass	%Alfalfa	%Grass
Planned Comparison	H2	H3	H2	H2	H3	H3
Avg. Spray	34.7	29.9	87.7	7.0	85.8	13.5
Avg. No Spray	35.6	32.8	88.6	7.0	86.6	12.4
p-value (trt)	0.7097ns	0.2232ns	0.4483ns	0.9546ns	0.5470ns	0.4107ns
p-value (trt*ent)	0.6563ns	0.1495ns	0.6857ns	0.3640ns	0.1609ns	0.2078ns
Avg. Resistant Alfalfa	34.9	30.9	86.6	8.1	85.1	14.1
Avg. Conventional Alfalfa	35.5	31.8	89.7	5.9	87.2	11.8
p-value (trt)	0.5120ns	0.2994ns	0.0098**	0.0020**	0.0437*	0.0310*
Avg. Alfalfa + Grass	35.9	32.3	86.0	9.4	81.9	17.3
Avg. Alfalfa	33.0	28.5	94.6	0.0	99.2	0.0
p-value (trt)	0.0072**	0.0006**	0.0001**	0.0001**	0.0001**	0.0001**

*=statistically significant at P=0.05; **=statistically significant at P=0.01, ns=not statistically significant.

Table 7. Number of Potato leafhoppers (10 sweeps per plot) at Harvest 2 in 2007.

	Number of PLH Harvest 2
Avg. Spray	0.29
Avg. No Spray	7.15
p-value (trt)	0.0129 **
p-value (trt*ent)	0.6168 ns
Avg. Resistant Alfalfa	3.40
Avg. Conventional Alfalfa	4.04
p-value (trt)	0.0506 *
Avg. Alfalfa + Grass	3.76
Avg. Alfalfa alone	3.58
p-value (trt)	0.5731 ns
PLH Alfalfa + Orchardgrass	4.17
Conv. Alfalfa + Orchardgrass	4.17
PLH Alfalfa + Tall Fescue	2.75
Conv. Alfalfa + Tall Fescue	4.83
PLH Alfalfa + Timothy	2.00
Conv. Alfalfa + Timothy	3.67
PLH Alfalfa alone	3.00
Conv. Alfalfa alone	5.17

*=statistically significant at P=0.05; **=statistically significant at P=0.01, ns=not statistically significant.